PHYSICS 312 — Spring 2015

Instructors:

Andriy Nevidomskyy BRK 305 ext. 6046. **e-mail**: nevidomskyy@rice.edu

Paul Stevenson HBH 240 ext. 5248. **e-mail**: stevenson@rice.edu

Lectures: M,W,F 11:00 – 11:50 am in HBH 21

Textbook: J. S. Townsend, *A Modern Approach to Quantum Mechanics* (University Science Books).

Additionally, a course packet of the lecture notes is available through the campus bookstore.

Office Hours: (i) The office hours are held in Prof. A. Nevidomskyy's office, BRK 305, on Fridays 3-4:30pm. (ii) Prof. Paul Stevenson is also available - please e-mail or call ahead to set up an appointment; suggest a couple of times that would be convenient for you. (iv) We are always happy to answer questions after class.

Homeworks: The Honor-Code pledge will not apply to the homeworks, but you should always try to work the problems on your own. Some discussion of the problems beforehand, and comparison of notes afterward is perfectly acceptable. Indeed, students are encouraged to help, and to learn from, each other. However, copying a solution from any source is not acceptable.

Homework is due *promptly* at the start of class at 11 a.m. on Mondays (unless a different day of the week is specified by the professor).

If, because of illness or special circumstances you will be unable to turn your homework on time, please inform me as soon as possible, preferably before the homework set is due. Unexcused late homeworks will be subject to penalties (mild for a first offence, but rapidly becoming more severe for repeat offences).

Examinations and Grading: Exams will be take-home, open-book, open-notes exams. No conferring on the exam problems is allowed, and the Honor-Code pledge will be required on the exam scripts. You should be familiar with the Rice Honor Code and know the proper wording of the pledge.

It is planned to have the Mid-Term exam around Feb. 20 – 27 (i.e., the week before Spring break).

Grading: Homeworks (35%), Mid-Term (30%), and Final (35%)

Aids to Study

Problem Solutions will be available in a ring binder kept at the Reserve Desk of the Library and updated regularly. A copy of the *Lecture Notes* will also be available from the Reserve Desk (or you can purchase them at Rice Bookstore). Students have generally found these materials very helpful and you should use them as a regular part of your study plan. The *Problem Solutions* may be copied by hand but are *not* to be Xeroxed or photographed, in whole or in part. (Hand copying, unlike Xeroxing or using the smart phone camera, passes through the brain.)

Some other course materials will also be posted on the PHYS 312 Owl-Space site, under "Resources."

Any student with a disability requiring accommodations in this course is requested to speak with the professor during the first week of class. Additionally, students will also need to contact Disability Support Services in Allen Center, Room 111.

PHYSICS 312 — Syllabus

Spring 2015

Text: Townsend, *A Modern Approach to Quantum Mechanics* (McGraw-Hill).

Brief review of key concepts and the Hydrogen-atom problem

Addition of Angular Momenta — Clebsch-Gordan Coefficients

Approximation Methods for Bound-State Problems.
- Variational method.
- Perturbation theory (time independent).
- Degenerate case.
- Zeeman effect without spin. Stark effect.

Fine Structure of Hydrogen
- Relativistic kinematic correction.
- Spin-orbit coupling.
- Zeeman effect with spin.

Identical Particles
- Bosons and fermions. Pauli Exclusion Principle.
- Interaction between identical particles — exchange term.

Multielectron Atoms
- Central-field approximation. Shell structure.
- Corrections to central-field approximation. Hund's rules.

Molecules
- Ionic and covalent bonds.
- Born-Oppenheimer approximation.
- Vibration and rotation spectra.

Time-Dependent Perturbation Theory
- General formalism. Harmonic case. Long-time limit.
- Fermi's Golden Rule.
- Interactions of atoms with classical electromagnetic fields.
- Adiabatic approximation. Sudden approximation.

Scattering Theory
- Born Approximation.
- Partial waves. Phase shifts. Optical theorem.
- Low-energy scattering: scattering length.

Mixed States and the Density Matrix

Brief introduction to Relativistic Quantum Physics
- Relativistic wave equations. Klein paradox.
- Free field theory. Quantized EM field; photons.

Course Objectives and Learning Outcomes

By the end of the course students should have:

1. An enhanced knowledge and comprehension of the mathematical structure of quantum mechanics — both the fundamentals, introduced in the preceding course, Phys 311, and the topics of angular-momentum addition, identical particles, and mixed-state density operators.

2. A practical ability to apply quantum mechanics to solve, exactly or approximately, a wide variety of simple (few-degree-of-freedom) quantum-mechanical systems, especially by the use of perturbation theory.

3. Some proficiency in predicting general qualitative properties of complicated and/or many-degree-of-freedom quantum systems from general principles.

4. An ability to assess (both *a priori* and *a posteriori*) the appropriateness of various approximation strategies in quantum problems.

5. A sound understanding of the application of quantum mechanics to atoms, including a detailed knowledge of knowledge of the Hydrogen-atom spectrum (its fine structure and its response to external electric and magnetic fields) and a qualitative understanding of multi-electron atoms and diatomic molecules.

6. A familiarity with time-dependent perturbation theory, scattering theory and and the basics of field quantization.